

Quality of energy-reduced muffin produced with whole-grain wheat flour, safe for diabetics' nutrition

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The aim of this research was developing a formulation for muffins, produced with whole-grain wheat flour, suitable and safe for nutrition of people with carbohydrate metabolism disorders (diabetics). Recommendations for diabetics' nutrition were analysed to develop a cake of appropriate quality and safe for consumption. The following matters were determined: (a) the essential parameters of technological and sensory quality of the final product; (b) the nature and quantity of basic ingredients, making five different model-samples of muffins; (c) moisture, ash, fat, salt, starch, protein, fibre and sugar content of cakes; (d) the quality of muffins was evaluated by descriptive sensory analysis; (e) nutritive composition was compared with similar products from the market. The basic chemical composition and the achieved quality of muffin-samples were analysed after production, and the best one was selected, produced combining following ingredients: 32% whole-grain wheat flour; 30% water; 10% skimmed milk; 9% fructose; 5% sunflower oil; 6.5% eggs; 3.2% fat-reduced cocoa powder; 3% yeast; 0.3% salt; 0.3% flavours (chocolate, vanilla, rum); 0.16% additives mixture. The cakes had a high overall sensory quality (4.73 ± 0.22 points of possible 5), characteristic regular shape and volume, uniform pores distribution, moderate elasticity and moisture during chewing, uniform dark brown colour, pleasant harmonious aroma and sweetish taste of baked chocolate cake. It was concluded that the muffins were suitable and safe for diabetics nutrition regarding basic ingredients content (whole-grain wheat flour, skimmed milk, fructose, vegetable oil) and nutritional composition with reduced content of: energy 30-54%, fats 30-79%, sugar 67-80%, when compared to five similar chocolate cakes, available on the market.

INTRODUCTION

Consumers usually choose food balancing between their desires, recommendations for healthy nutrition, if they know them, and food products available on the market (Grujić et al., 2013a, b; Grujić & Grujić, 2016, 2017; Grujić & Odžaković, 2017). Every day in the world, the number of people with various obesity-related health problems is increasing, including those with diabetes (Karp et al., 2016; Lee & Puligundla, 2016). The World Health Organization (WHO) recognised the nutrition and physical inactivity as factors with great impact on health (WHO, 2015; WHO ROE, 2015), and that is one of the reasons for expected and evidenced increase in demand for products with controlled and acceptable nutritional and sensory quality. Therefore, food products may differ in nutritional composition and quality, but some of them may be suitable for nutrition

of persons with certain health disorders or diseases. Modern technology made it possible to combine different ingredients and develop new products with a quality tuned to the identified consumers' needs and expectations (Hussein et al., 2018; Sajdakowska et al., 2018a, b; Song et al., 2019). At the same time, food industry may use actual situation as an opportunity for increasing volume of production in the field of its business. However, acceptance of products with modified composition, as is energy-reduced food, could be related to the problems regarding lower or poor sensory quality and despite overall nutritive value, the popularity and sale of such food products could be limited (Kiharason et al., 2017; Lee & Puligundla, 2016). New food products developing is complex and includes marketing, technology and consumer researchers knowledge (Grujić & Grujić, 2016, 2017; S. Grujić & R. Grujić, 2011, 2012; Horvat et al., 2019).

Diabetes mellitus (also known as diabetes) is a group of metabolic diseases, identified as one of the leading diseases in the world, with a tendency to spread and arise as a result of the interaction of various factors, the

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most important of which are genetic factors, lifestyle and environmental influences (Popović-Pejičić et al., 2016). Different information and recommendations for consumers' diets are available today. The importance of proper nutrition is emphasised in the first place, and it is recommended for all people as a way of maintaining good health. It is also a prerequisite for reducing the risk of chronic diseases developing, especially for nutrition of persons with diabetes (Prašek & Jakir, 2009). The requirements for quality of food for special dietary needs are prescribed (Regulation (EU) No 609/2013; Službeni glasnik BiH, br. 72/11), the same as general and specific conditions for quality and safety of all food items in common use are prescribed and applied.

Wheat flour is used as basic ingredient in a variety of food and bakery products (Kiharason et al., 2017). All consumers are familiar with the large number of food products belonging to the fine bakery products category. They differ in the basic technological process of production, ingredients or/and overall quality characteristics. Sweet, fine bakery products, such as cakes, cookies, muffins and biscuits are especially interesting and popular. Some of them could be made with whole-grain wheat flour. The dough for such bakery products is made by an appropriate

technological process from mixed mill products, water, with or without yeast or dough rising agents, table salt, and other ingredients that give a specific quality to the products (Grujić, 2018; Službeni glasnik BiH). Consumers of all ages like to eat and enjoy pleasant sensory properties and differences in quality characteristics of fresh-baked fine bakery products or cakes. The commercial aspect of their quality is interesting, because they are usually cheap.

The aim of this research was developing a formulation for energy-reduced muffins, produced with whole-grain wheat flour (WGWF), suitable and safe for nutrition of people with carbohydrate metabolism disorders (diabetics).

MATERIALS AND METHODS

Material used for the experiment

Muffins were produced in the laboratory by selecting the appropriate ingredients for the planned research and developing the formulation. Ingredients used for the energy-reduced muffins development and production are presented in Table 1.

Table 1. Ingredients used for muffins production

Ingredient	Producer
Whole-grain wheat flour	Žitoprodukt 2012 d.o.o, Banja Luka, BA
Sterilised skimmed milk with 0.90% milk fat	Mlijekoprodukt d.o.o, Kozarska Dubica, BA
Tap water (medium hard)	public supply system in Banja Luka, BA
Fresh eggs (53-63g /piece)	Agreks d.o.o. Donji Žabar; BA
Low calorie sweetener with maltitol 99.2% and steviol glycosides 0,8%	Vitalia Nikola Ltd, The health Food Company, Skopje, N. Macedonia
Fructose crystal	Lučar d.o.o., Novi Sad, Serbia
Fat-reduced cocoa powder with 10-20% cocoa butter	Podravka d.d. Koprivnica, Croatia
Margarine, 70% Fat spread [Ingredients: vegetable fats (palm, coconut), water, vegetable oils (sunflower, rapeseed), table salt 0.4%, emulsifier E471, preservative E200, acidity regulator citric acid E330, aroma, colour beta-carotene]	Zvijezda d.d., Zagreb, Croatia
Sunflower oil	Floriol, Hungary
Fresh yeast with minimum 28% dry matter	(Kvasac d.o.o. Prigorje Brdovečko, Croatia
Baking powder - Dough rising agent (Ingredients: emulsifier E450a, rising agent E 500b, corn starch)	Dr. Oetker Kft, Franck, Hungary
Citric acid E 330	MLADEGS PAK d.o.o. Prnjavor, BA
Table salt with 20-30 mg iodine/kg salt	Solana d.d. Tuzla, BA
Food additives mixture for improving the quality of bakery products: SUPER for improving the quality of wheat flour (S-improver) and RELIQUUS for the maximum volume (R-improver);	Progres d.o.o. Novi Sad, Serbia
Food flavours Chocolate, Vanilla and Rum, each of them in concentration 1:100	Eterika d.o.o., Trstenik, Serbia

Methodology of the research

Recommendations for diabetics' nutrition were analysed to select ingredients for muffins production and to achieve appropriate product quality, to be suitable and safe for nutrition of people with diabetes. The preparation of energy-reduced muffins with WGWF and cocoa included five consecutive tests, until the appropriate quality of the finished products was achieved. Analytical methods for quality control of produced muffins included chemical and sensory analysis. Initial formulation for cake-samples production was the base for further modelling and products quality improving. Quantitative Descriptive Analysis (QDA) was used as a tool for selected products with sensory quality parameters evaluation and non-compliances identification. After sensory evaluation of the first experimental batch of baked muffins, the formulation for the second batch was modified and procedure successively repeated until the expected product quality was achieved in the fifth batch.

The muffins production included several operations, combining the basic ingredients in different quantities, as follows: preparation of the ingredients according to the formulation, mixing, fermentation, baking and cooling. The required amounts of ingredients were weighed (± 0.1 g) and added with heated water/with milk (28°C) in a bowl of electric mixer (CLATRONIC, maximum capacity 2 kg/container), mixed by hand and then with a mixer medium speed for 10 min, to achieve a homogeneous, moderately thick and creamy consistency.

The first fermentation in a mass was carried out for 30 min (at 28°C), and after that 80 g of dough was dosed manually into each of 12 paper cups in a muffin pan. The cup of the muffin pan had 55 mm upper diameter, 35 mm height. A second fermentation was carried out for 10 min at temperature 28°C, and after that the cakes were baked in the electric oven (Candy S.p.A. Italy) for 15-20 min at 180°C, and cooled to room temperature.

The average weight of baked muffins was 60-70 g, and they were stored in plastic polypropylene containers with lids at room temperature. The final formulation for muffins processing method, ingredients and quality parameters were defined during product development.

Chemical analysis

Baked muffins were cooled at room temperature for 2 hours, and then packed in polyethylene, plastic bags, signed and stored frozen (on -18°C) before chemical analysis. The proximate composition of produced cakes was determined according to the Association of Official Agricultural Chemists (AOAC) standard methods (2000): moisture, total fat, ash content with

three repetitions, and two repetitions for the others, respectively: NaCl, total proteins, total dietary fibre, starch and sugar. The results are presented as mean \pm standard deviation. Total carbohydrate content was calculated by the following equation: $100 - (\text{water} + \text{protein} + \text{total fat} + \text{total ash} + \text{total dietary fibre} + \text{salt})$ content, according to Doménech-Asensi et al. (2016).

Descriptive sensory analysis

Experimental cakes production and quality control were realised in laboratory conditions at the Faculty of Technology, University of Banja Luka, Bosnia and Herzegovina (BA) in the Laboratory for food sensory analysis, designed and equipped according to the Standard ISO 8589:2007, and in the Laboratory for food analysis.

Five trained panellists were recruited (ISO 6658:2005; ISO 8586-1:1993) for muffins Quantitative Descriptive Analysis (QDA) by consensus scoring method (Grujić, 2015; ISO 4121:2003; ISO 11037:2011; ISO 13299:2003; ISO 11035:1994; ISO 11036:1994). Panellists evaluated each of five different experimental batches of muffins samples (A, B, C, D, E), one sample/day, using QDA by consensus scoring method.

After production and selection the best baked muffins samples and batch formulation, muffins Individual QDA was organised with twenty panellists, the students and teaching staff from the Faculty of Technology, University of Banja Luka (BA), recruited for the sensory analysis as permanent consumers of cakes and similar bakery products. They were verified and trained for objective evaluation and scoring, following the standard procedures (ISO 6658:2005; ISO 8586-1:1993). They worked in four groups of five panellists.

According to standard procedures, the muffin samples were served in the individual sensory booths, at room temperature, on white plates together with knife, white paper napkins, glass cup with water (20–23°C) for the mouth rinsing and cleansing the palate, containers for sputum, pencil and evaluating form. Sensory analysis of the samples was performed 12h after baking, and the samples were stored at room temperature (20–23°C) in closed plastic containers with lids.

The appropriate attributes, selected as useful for a detailed, illustrative descriptive sensory analysis of important properties and variations in quality of energy-reduced muffins with WGWF and cocoa were presented in the form, prepared for cake sensory evaluation. The following sensory attributes were analysed and evaluated: (A) Appearance of cake (shape, volume, appearance of upper surface, lower surface and cross-section); (B) Colour of cake cross-section, the same as colour of top and bottom surface panellists analysed visually; (C) Cake texture panellists

analysed by sight, with fingers, and oral in the mouth (as hardness at the bite, elasticity during 3-4 first chews and humidity during chewing); (D) Taste and (E) aroma of cake panellists analysed during chewing, after putting a portion of the sample in the mouth.

Panellists were instructed to evaluate intensity for the selected sensory attributes using 5-point scoring system, as follows: appropriate quality (5); slight deviation (4); noticeable deviation (3); clear deviation (2); unacceptable quality (1).

Nutritive composition and energy value of cakes

Conditions for nutritive information labelling on packaged food are prescribed by the provision of food information to consumers (Regulation (EU) No 1169/2011; Službeni glasnik BiH, br. 68/13). The nutritive composition was determined based on average values obtained through: food analysis and calculation of known average values for used ingredients and expressed per 100 g of product. The energy value of the new product was compared with selected labelled nutritive data for five different cakes (products) purchased on the market in Banja Luka (BA) and marked as K_n (for $n=1, 2, 3, 4, 5$). They were selected by taking into consideration quality characteristics of muffin-type chocolate biscuit-cakes with wheat flour and other ingredients that are usually used for their production. Information about the origin of purchased products is not presented in the paper, but is known to the author.

RESULTS AND DISCUSSION

The experimental part of this research was realised in order to develop formulation for the production of energy-reduced muffins with WGWF and cocoa, which, regarding ingredients, composition and sensory quality, would be suitable for the diet of people with carbohydrate metabolism disorders (diabetics).

Analysis of recommendations for diabetics' nutrition and food product ingredients

The nutrition of persons with diabetes is a form of a balanced diet, similar to healthy people, but they must achieve intake of energy, vitamins, and minerals during the day (Prašek & Jakir, 2009). Doctors and nutritionists believe that a controlled diet for diabetics should be adapted to the principles of proper, balanced and varied diet, so specific guides for clinical practice for diabetes mellitus were developed (Popović-Pejičić et al., 2016). They emphasise the importance of a controlled diet, as one of several important forms of diabetics' treatment, which are intertwined at the same time. Such a diet involves combining a certain amount of selected food and nutrients in the daily

meal, determined on an individual level, adapted to the consumers' needs and distributed in several meals during the day, including carbohydrates, proteins and fats, vitamins, minerals and water.

In addition, it recommends wholemeal flour consuming and appropriate food products with dietary fibre, enough proteins, controlled sugar intake in the form of fructose, the fat content to be lower and to use fats of vegetable origin (Popović-Pejičić et al., 2016). Consumption of food products with lower glycemic index, as are products with integral wheat flour, is recommended and suitable for diabetics, because of lower rise in blood glucose amount than after consuming products with white wheat flour (Dorothee et al., 2012). Dietary fibres are also produced and widely available as innovative, healthy and multifunctional food ingredients. Different studies were realised trying to replace part of the fat with fibres in sweet bakery products (Martínez-Cervera et al., 2011).

Individual nutrition for people with diabetes should be based on a balanced diet as well as personal and cultural preferences, but a serious problem for them is meal planning and making decision what sweet to eat, regarding limited access to healthy sweet fine bakery products or cakes. That is why this research aimed to offer solution by developing products with lower sugar and fat content, but with a quality comparable to similar traditional bakery products.

Ingredients selection and muffins A-sample modelling

Based on the recommendations for diabetics' diet, WGWF was selected as basic ingredient for the research and muffins cake production, as a natural source of dietary fibre. The steviol glycosides, as low-energy sweeteners, have limited use in fine bakery products (Grujić, 2018; Regulation (EC) No 1333/2008. Commission Regulation No 1131/2011; Službeni glasnik BiH, br. 33/18). Natural sweetener stevia (steviol glycosides E960) could replace sucrose in bakery products, for reducing energy intake. However, decreased content or full sugar replacement in dough could affect the quality of sweet baked product, so it demands formulation optimising for different food products and processing methods (Huzjak, 2012; Karp et al., 2016).

The basic ingredients used for experimental cakes production are shown in Table 1 and Table 2. For production of first, A-sample of energy-reduced muffins, the following ingredients were used: whole-grain wheat flour; skimmed milk; low calorie sweetener (maltitol 99.2% and steviol glycosides 0.8%); fresh eggs; fat-reduced cocoa powder; margarine and salt.

Fibre is an important component in whole-grain wheat cakes production, because of its favourable nutritional quality. However, the development of tasty, health-

Table 2. Formulation for basic ingredients for muffins production in percentages based on flour weight

Ingredients	Ingredient content (%) in raw dough for muffin samples				
	A-sample	B-sample	C-sample	D-sample	E-sample
Whole-grain wheat flour	100.0	100.0	100.0	100.0	100.0
Skimmed milk	95.0	27.8	27.8	31.2	31.2
Water	-	73.0	73.0	93.8	93.8
Fresh eggs	20.8	19.4	19.4	20.3	20.3
Sweetener	12.5	-	-	-	-
Fructose	-	19.4	19.4	28.1	28.1
Cocoa powder	4.0	13.9	13.9	10.2	10.2
Margarine	10.0	-	-	-	-
Sunflower oil	-	13.9	13.9	15.2	15.2
Fresh yeast	5.0	6.9	6.9	9.4	9.4

Table 3. Formulation for other ingredients for muffins production in percentages based on flour weight

Ingredients	Ingredient content (%) in raw dough for muffin samples				
	A-sample	B-sample	C-sample	D-sample	E-sample
Baking powder	2.2	-	-	-	-
Citric acid	0.1	-	-	-	-
Salt	0.4	1.4	1.4	1.0	1.0
Additives mixture (S-improver)	-	0.5	-	-	1.9
Additives mixture (R-improver)	-	-	0.5	1.9	-
Chocolate flavour	-	0.8	0.8	0.9	0.9
Vanilla flavour	-	0.3	0.3	0.9	0.9
Rum flavour	-	0.3	0.3	0.9	0.9

promoting food products, rich in cereal grains and fibres is a technological challenge regarding achieving expected sensory quality (Almeida et al., 2013; Gębski, et al., 2019). It is known that WGWF gives a lower technological quality of dough compared to white flour, so dough rising agent and citric acid were used, with the usual amount of fresh yeast, to improve muffins dough quality. However, sensory analysis revealed that shape and volume of the muffin A-sample was not satisfactory (Table 4), as upper surface was flat, the cake was too hard with insufficient porosity and rough, dry cross section. In addition, the cake was not elastic enough when pressed with fingers and torn, and it was rough and dry during chewing. A better quality of the cakes aroma and fullness of taste were expected, with skimmed milk use for the first muffins

batch preparation, but the result was not as expected. The biscuit was not porous and tender enough, due to the higher proportion of flour, indicating that a smaller amount of flour could be used in the next formulation.

The aroma of baked WGWF and cocoa was pleasant during chewing of warm and chilled muffins. The amount of cocoa and margarine, used for cake preparation, was not enough to achieve the satisfactory aroma and fullness of the taste. Salt amount affects the dough quality and gives a more pleasant taste. However, salt omission is not recommended because completely unsalted dough seems bland, even in a sweet product. Brown colour was lighter than planned for a chocolate biscuit (Table 4). Food additives from the sweeteners category were used (Table 2) to achieve sweet taste,

Table 4. Results of muffins descriptive sensory analysis by consensus scoring method (for n=5 panellists)

Sensory properties of muffins	Samples code and sensory scores*				
	A	B	C	D	E
(A) CAKE APPEARANCE	2.5	3.0	3.0	4.0	5.0
A.1. Shape	3.0	3.0	3.0	4.0	5.0
A.2. Volume	2.5	3.0	3.0	4.0	5.0
A.3. Appearance of upper surface	2.5	2.5	2.5	4.0	4.5
A.4. Appearance of lower surface	3.0	4.0	4.0	5.0	5.0
A.5. Appearance of cross-section	2.5	3.0	3.0	4.0	5.0
(B) CAKE COLOUR	3.0	5.0	5.0	5.0	5.0
B.1. Top surface colour	3.0	5.0	5.0	5.0	5.0
B.2. Bottom surface colour	3.0	5.0	5.0	5.0	5.0
(C) CAKE TEXTURE	2.5	3.5	3.5	4.5	5.0
C.1. Hardness at the bite	2.5	3.0	3.0	4.0	5.0
C.2. Elasticity during chewing (first 3-4 chews)	2.5	3.0	3.0	4.5	5.0
C.3. Humidity during chewing	2.5	3.5	3.5	5.0	5.0
D) CAKE TASTE	3.0	3.5	3.5	5.0	5.0
E) CAKE AROMA DURING CHEWING (retronasal)	3.0	3.5	3.5	5.0	5.0
SCORE FOR OVERALL QUALITY	2.7	3.6	3.6	4.5	5.0

*Evaluation of each sensory property and identified deviations in cake quality scored: appropriate quality (5); slight deviation (4); noticeable deviation (3); clear deviation (2); unacceptable quality (1).

but a mild and recognizable bitterness in the chilled product, originating from sweeteners, WGWF and cocoa, were identified as noticeable deviation in taste quality (Table 4).

Sweet bakery products, as biscuits or muffins, are popular because of their soft texture, great taste and aroma. Muffin batter is a complex aerated emulsion of egg-sucrose-water-fat mixture, which during baking form a desirable porous structure and high volume with uniform bubbles distribution. As traditional muffins have high sugar and fat content, it is important to find a solution for limiting sugar addition and decreasing the energy value of sweet bakery products. It is possible to replace sugar with sweeteners or to modify formulation. However, sugar is important for appropriate sensory and overall quality of a bakery product, especially for texture, colour, moisture, flavour, and taste, and their replacement usually has negative impact on some or all of them (Karp et al., 2016). Other research confirmed that it is also hard to replace fats or oils in formulation for muffins, and to have acceptable technological and sensory quality. For example, the low-fat chocolate muffins made by partly replacing the oil ingredient with soluble cocoa fibre were increasingly more cohesive and more difficult to

chew and swallow when higher level of cocoa fibre was added (Martínez-Cervera et al., 2011).

Muffins technological and sensory quality improving by B-sample and C-sample modelling

WGWF is valuable healthy, functional food, often used for bakery and bakers confectionery products fortification. Integral wheat flour contains coarse particles that have a positive influence on higher water-binding capacity, but the problem is that gas retention in the dough is lower and the volume of the finished product is smaller (Dorothee et al., 2012). The formulations for the B and C-samples were modified to achieve better technological and sensory quality of the dough, so amount of flour was reduced (to be 4% less than in A-sample), while cocoa and fresh yeast were increased. Food additives mixture for improving the quality of bakery products (S-improver for B-sample; R-improver for C-sample) were used in the quantities that manufacturer recommended, instead of dough rising agents and citric acid, used in the first sample production. Salt quantity was somewhat increased (Table 3) to improve technological properties of the dough with the yeast. Sensory analysis showed that the colour of the muffins-like cakes with whole-grain wheat flour and cocoa was appropriate (Table 4),

dark brown like chocolate, but the taste was slightly bitter with too strong cocoa aroma, indicating that there should be smaller amounts of cocoa in the cake (Table 2). Chocolate and cocoa are favourite ingredients of sweets, cakes and bakery products for numerous consumers of all ages, so cocoa was selected as ingredient to achieve better colour and aroma of whole-grain wheat flour cake. The addition of chocolate, vanilla and rum food flavours (Table 3) improved the aroma of the muffins-like cakes with cocoa. The chocolate aroma was pleasant during bites chewing, sufficiently expressed in combination with cocoa, but the quantity of each flavour of vanilla and rum, could be increased in the next batch of samples, to be sufficiently rich, discreet and expressive, similar to chocolate.

Special attention is given to global obesity increase, as a problem strongly connected with overconsumption of food rich in sugar and fat. Furthermore, consumers care about food products quality, nutritional benefits of food and their ingredients for health (Karp et al., 2016; Lee & Puligundla, 2016). Texture and colour are important indicators of sensory quality for fine bakery goods, biscuits or muffins. However, when reducing or completely replacing of sucrose is planned, it may decrease the quality of texture and colour in bakery products, or increase lightness comparing to traditional formulations (Karp et al., 2016). During the realisation of the experiment, it happened that the low-energy sweeteners use in bakery products and biscuits were prohibited, while polyols could be used (Regulation (EC) No 1333/2008), but they have a laxative effect when used in higher quantity in food. Therefore, fructose was selected as better solution, because it is recommended for use as an ingredient of food products suitable for diabetics (Popović-Pejičić et al., 2016; Song et al., 2019). The quantity of fructose in cake was determined in order to give a sufficiently sweet taste, proportional to the 10-15% sucrose.

Fat provides the highest energy value as food constituent, and its reduction or substitution by other ingredients, regarding energy-reduction, is a challenge for bakery products. Fat improves texture, mouth-feel and flavour, and provides higher volume and softness in baked cakes (Hussein et al., 2018). Initially, a selection of ingredients for muffins A-sample was used as frame for further formulation modelling. As A-sample had a rather hard texture and volume lower than expected (Table 4), the amount of added liquid was increased for B, C, D, E-samples production (Table 2). Furthermore, fructose was used instead of food additives sweeteners, sunflower oil instead of margarine (both selected as vegetable fats), to achieve better softness and elasticity. Also, milk was partly substituted with combination of 1 part milk (10%) and 3 parts of water (30%) in the total amount of raw dough, adjusted to the amount

of used wholemeal flour and other ingredients (Table 2 and Table 3). All mentioned changes in formulations improved cakes sensory quality, gave better texture, elasticity and juiciness during chewing. However, the volume of muffin was relatively lower than expected, the porosity of the biscuit was not satisfactory, and the upper surface was horizontal, instead of slightly convex (Table 4). All mentioned above indicated the need for further modelling of the formulations.

Defining ingredients quantity in formulations for muffins D-sample and E-sample

As B and C-samples of the energy-reduced muffins have not had the expected quality, in the formulations for D and E-samples the amount of flour was reduced to be 4% less than in B or C-samples; and the same amount of water was increased for balance, resulting in better quality.

The proteins from gluten are important ingredients of wheat flour, responsible for building structure of the bakery product, higher elasticity and better ability to retain gas in dough. In addition, molecules of starch contribute to the quality of product structure during baking, while swelling, and alter the structure taking other forms (Kiharason et al., 2017; Song et al., 2019).

The amount of fresh yeast was increased, while salt was reduced in the total amount of dough (Table 2), taking into account the recommendations of nutritionists on salt reducing in the daily meal. It is important to keep minimal salty taste and to get expected volume and porosity of cake after baking, as technological and sensory quality. The analysed sensory characteristics of muffins D and E-samples were better than for B and C-samples, and all of them were better than muffins A-sample (Table 4). The D and E-samples had appropriate, moderately sweet and full taste, with used quantity of cocoa and fructose. Their aroma was improved, discreetly rich and expressive, as a result of balanced addition of ingredients and chocolate, vanilla and rum flavours (Table 3).

The dietary requirements of modern consumers are changing along with the changes in the conditions of their lives and work, so preference is now expressed towards food products with controlled nutritional composition, which are healthy, safe for consumption and with appropriate sensory quality (Gómez et al., 2002; S. Grujić & R. Grujić, 2011). Bakery products with WGWF are valuable products, rich in starch and energy, but also have a relatively high content of vitamins, minerals, trace elements and dietary fibre, essential amino acids and a low fat content, which are mainly contained in wheat germ and bran (Youssef, 2015).

Comparing D and E-sample quality characteristics revealed that muffin E-sample had appropriate technological and sensory quality (Table 4). The basic difference between D and E-sample muffins formulation was in used food additives mixture for improving the quality of bakery products (Table 2), where S-improver impact on better volume of E-samples than of D-samples produced with R-improver (Picture 1). Therefore, it can be concluded that the basic ingredients for energy-reduced muffins production were selected and used in the following optimal quantities (expressed in percentages based on flour weight): 100% whole-grain wheat flour; 93.8% water; 31.2% skimmed milk; 28.1% fructose; 15.2% sunflower oil; 20.3% eggs; 10.2% fat-reduced cocoa powder; 9.4% yeast; 1.0% salt; 0.9% of each flavour (chocolate, vanilla, rum); 1.9% S-improver additives mixture SUPER for improving quality of bakery products.

The relationship between used ingredients could be better visible when expressed in percentages based on weight of row dough for E-sample muffins, as follows: 32% whole-grain wheat flour; 30% water; 10% skimmed milk; 9% fructose; 5% sunflower oil; 6.5% eggs; 3.2% fat-reduced cocoa powder; 3% yeast; 0.3% salt; 0.3% flavours (chocolate, vanilla, rum); 0.16% S-improver additives mixture SUPER for improving the quality of bakery products.

Descriptive sensory analysis of energy-reduced E-sample muffins, as new product

After successful new product development in the laboratory conditions, according to the defined formulation and production process, further work required sensory evaluation to confirm the achieved quality.

People with health problems need specific quality of nutrition and that area opens opportunities for food industry to expand the volume of business, offering new products with quality adjusted to the target group of consumers. At the same time, such activities can contribute to better conditions for the nutrition of

people with health problems (Huzjak, 2012; Kiharason et al., 2017; Sajdakowska et al., 2018a, b). Consumers' habits in most countries are characterised by a high consumption of different bakery products made with cereal flours, as cakes, cookies, biscuits, and muffins (Doménech-Asensi et al., 2016; Lee & Puligundla, 2016). Usually, they have a higher energy value, as products rich in sugar and fats.

In this context, the defined aim of the research and quantitative descriptive sensory analysis was to evaluate the achieved quality of energy-reduced muffins with whole-grain wheat flour and cocoa (E-sample), as selected new product, suitable for diabetics' diet and for modern consumers who like sweet bakery products and care about individual nutrition.

Typical characteristics of muffins quality were selected, and used as parameters for sensory evaluation, including appearance, colour, shape and volume, taste, aroma, texture and overall quality, model similar to research that was realised by Lee and Puligundla (2016). The cake should have a uniform brown colour, proper characteristic shape and volume with uniform distribution of pores, moderate elasticity, and moderate humidity during chewing, pleasant harmonious sweet taste and rich aroma of baked chocolate biscuit.

During the sensory analysis, it was found that the E-sample of the energy-reduced muffins-like cakes with whole-grain wheat flour and cocoa (Picture 2) had the appropriate shape (score 5), the volume was slightly deformed (grade 4.85), but very good. The appearance of the upper cakes surface had a slight deviation from the expected quality (grade 4.05), due to the observed smaller and larger cracks on the upper surface of the analysed samples, with a slight or fine surface roughness, acceptable for muffins (Table 5). Small and rough cracks were visible on the lower surface of the cake, as well as slight roughness (score 4.44). The identified smaller defect in quality was acceptable, as the cake was produced with integral wheat flour. The cross-sectional appearance was adequate, regular (score 4.83), with properly spaced pores. The colour



Figure 1. Muffin D-sample (left) and E-sample (right)



Figure 2. Muffin E-sample

Table 5. Results of muffins E-sample descriptive sensory analysis (for n=20 panellists)

Sensory properties of muffins E-sample	Mean score*
(A) CAKE APPEARANCE	4.56±0.31
A.1. Shape	5.00
A.2. Volume	4.85±0.37
A.3. Appearance of upper surface	4.05±0.32
A.4. Appearance of lower surface	4.44±0.06
A.5. Appearance of cross-section	4.83±0.18
(B) CAKE COLOUR	4.86±0.07
B.1. Top surface colour	4.81±0.08
B.2. Bottom surface colour	4.92±0.02
(C) CAKE TEXTURE	4.78±0.28
C.1. Hardness at the bite	5.00±0.00
C.2. Elasticity during chewing (first 3-4 chews)	4.87±0.33
C.3. Humidity during chewing	4.86±0.31
D) CAKE TASTE	4.60±0.12
E) AROMA OF THE CAKES DURING CHEWING (retronasal)	4.85±0.02
MEAN SCORE FOR OVERALL QUALITY	4.73±0.22

* Results are presented as mean \pm standard deviation for n = 20 measurements. Evaluation of each sensory property and identified deviations in cake quality scored: appropriate quality (5); slight deviation (4); noticeable deviation (3); clear deviation (2); unacceptable quality (1).

of the upper cakes surface was uniform, brown, with slight acceptable deviations (mean score 4.81), similar to the bottom surface (mean score 4.92). The texture of the cake was appropriate (mean score 4.78), confirmed by the analysis of bite hardness (score 5), elasticity (score 4.87) and moisture (humidity) during bites chewing (score 4.86).

The taste of the energy-reduced muffins with WGWF and cocoa was appropriate (score 4.60), with a harmony of sweetness and slight bitterness that can be tolerated, as it comes from WGWF and cocoa. The aroma of the cake, analysed by the retronasal method, was appropriate (mean score 4.85), described as a harmony of cake, baked dough and cocoa–chocolate aroma.

Based on the results of the analysis of selected sensory quality characteristics of energy-reduced muffins with WGWF and cocoa, with improved health benefits, it can be concluded that a high level of overall cake (sample-E) quality was achieved (Table 5). Average score was very high (4.73), if it is known that 5 was the highest possible score for the appropriate quality.

Chemical composition of muffins

The chemical composition of analysed energy-reduced muffins with WGWF and cocoa is presented in Table 6. Analysis of five muffins model-samples (A, B, C, D, E) included determination of moisture, total fat, ash content, NaCl, total proteins, total dietary fibre, starch and sugar. The content and interrelationship of the ingredients defined by the formulation and used for the dough preparation, influenced the identified differences in the chemical composition of analysed baked muffins, as final products. They were acceptable, expected and similar to the usual changes in other cakes production, during fermentation, baking and cooling (Karp et al., 2016; Lee & Puligundla, 2016; Martínez-Cervera et al., 2011; Youssef, 2015). The most important ingredients that affect the quality of biscuit during technological process realisation are flour, protein, starch, fibre, water, fat and sugar (Doménech-Asensi et al., 2016; Gomez et al., 2002; Hussein et al., 2018; Kiharason et al., 2017). The muffins with WGWF and cocoa contain a proper quantity of carbohydrates, fat, fibre and protein to provide adequate quality. The presented results of development the energy-reduced muffins with WGWF are in accordance with recommendations for higher consumption of cereals and cereal-derived food products, with lower sugar and fat content, and they can be part of healthy and balanced diet.

Table 6. Chemical composition (dry weight basis) of baked energy-reduced muffins

Sample	Ash* (%)	Moisture* (%)	NaCl* (%)	Starch* (%)	Total proteins* (%)	Total fat* (%)	Total dietary fibre* (%)	Sugar* (%)
A	1.95±0.09	37.86±0.01	0.67±0.02	33.68±2.15	9.19±0.25	4.87±0.20	2.06±0.38	0.93±0.67
B	1.95±0.04	37.01±0.04	0.87±0.04	27.48±1.20	8.69±0.22	7.44±0.58	1.28±0.16	5.42±0.21
C	2.05±0.04	36.39±0.15	1.06±0.00	28.78±1.00	8.76±0.00	7.31±0.31	1.25±0.34	5.89±1.07
D	1.38±0.14	44.04±0.01	0.78±0.02	23.27±2.48	7.18±0.08	6.71±0.07	2.37±0.17	9.33±0.89
E	1.43±0.02	41.38±0.00	0.75±0.04	23.07±0.57	7.69±0.08	7.23±0.45	1.29±0.00	9.60±0.09

*Results are presented as mean ± standard deviation

Nutritive composition and energy value of muffins compared with similar products

The calculated nutritive composition showed that 100 g of energy-reduced muffins with WGWF contains: energy expressed as 1092 kJ (260 kcal); 7.23 g fats, 40.23 g carbohydrates, of which 9.60 g sugar; 1.29 g dietary fibre; 7.69 g proteins and 0.75 g NaCl.

It is prescribed (Regulation (EU) No 1169/2011; Službeni glasnik BiH, br. 68/13) that the claimed meaning that a food is energy-reduced on packed food may only be made where the energy value is reduced by at least 30 %, with an indication of the characteristics, which makes the food reduced in its total energy value. A new product, muffin with WGWF and cocoa (E-sample formulation) was compared in energy, fat and sugar content with five different cake samples (marked K_n , for $n=1, 2, 3, 4, 5$), used as control, to examine whether the new product can carry energy-reduced label. The analysis described above confirmed that the energy value of new muffins is significantly reduced, 30-54 % when compared to each of control samples (K_1 – K_5), as shown in Table 7. The proportional

differences exist in fats content (30-79%) and sugar content (67-80%). The identified difference confirmed success in development of new energy-reduced muffins with whole-grain wheat flour and cocoa, as with lower sugar and fats content.

CONCLUSION

Individual nutrition for people with diabetes should be based on a balanced diet, personal and cultural preferences, but when they wish something sweet to eat, the problem is in limited access to healthy sweet fresh-baked fine bakery products or cakes. That is why this research aimed to offer a solution by developing products with lower sugar and fat content, but with a quality comparable to similar traditional bakery products. This study provides methodology for new product development, energy-reduced muffins with whole-grain wheat flour and cocoa that has lower sugar and fats content, when compared to similar products. Regarding that, the cake is suitable and safe for nutrition of people with carbohydrate metabolism disorders (diabetics), as well as for healthy people.

Table 7. Relationship between muffins (E-sample) and control cakes (K_n) regarding reduced energy value

		Sample code for compared cakes					
Quantity in 100g of cake		E	K_1	K_2	K_3	K_4	K_5
Energy	(kJ)	1092	2360	2042	1855	1620	1565
	E/ K_n (%) ^a	-	46	53	59	67	70
Fats	(g)	7.23	34.50	27.60	27.00	19.00	10.40
	E/ K_n (%) ^a	-	21	26	27	38	70
Sugar	(g)	9.60	47.50	30.70	27.00	31.00	29.39
	E/ K_n (%) ^a	-	20	31	36	31	33

^aRelationship between muffins (E-sample) and chocolate cakes used as control (K_n), for energy, fat and sugar content expressed as percentage regarding reduced energy value.

The methodology for the new product development included defining the formulation for cakes production, ingredients selection, processing method description, as well as establishing standards for expected sensory and nutritive quality of the final product. It is important to point out that together with mentioned specific quality characteristics, new bakery product has additional value, as it is relatively cheap and suitable for industrial production. The results of research could also be used as a model for further scientific work and development of different new food products, intended for selected target groups of consumers.

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Kvalitet muffina smanjenog sadržaja energije, proizvedenih sa integralnim pšeničnim brašnom, bezbjednih za ishranu dijabetičara

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Ključne riječi:

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Individualna ishrana osoba sa dijabetesom treba biti zasnovana na balansiranoj dijeti, ličnoj naklonosti i kulturološkim specifičnostima, ali kada oni poželeva jesti nešto slatko, nailaze na problem sa ograničenom ponudom slatkih svježe-pečenih pekarskih proizvoda ili kolača koji imaju kvalitet usaglašen sa preporukama za pravilnu ishranu. To je bio motiv za naučni pristup istraživanju i pronalazanju rješenja, kroz razvoj novog proizvoda sa karakteristikama kvaliteta sličnim tradicionalnim pekarskim proizvodima, ali sa sastojcima koji se preporučuju u ishrani dijabetičara, kao i sa manjim sadržajem energije, šećera i masti. Cilj ovog istraživanja bio je razvoj recepture za muffine proizvedene sa integralnim pšeničnim brašnom, pogodne i bezbjedne za ishranu osoba sa poremećajem metabolizma ugljikohidrata (dijabetičara). Analizirane su preporuke za ishranu dijabetičara, da bi se proizveli kolači odgovarajućeg kvaliteta i bezbjedni za konzumiranje. Određeni su: (a) bitni parametri tehnološkog i senzornog kvaliteta gotovig proizvoda; (b) vrsta i količina osnovnih sastojaka, izradom pet različitih model-uzoraka muffina; (c) sadržaj vlage, pepela, masti, soli, skroba, proteina, vlakana i šećera u kolaču; (d) deskriptivnom senzornom analizom ocijenjen je kvalitet muffina; (e) nutritivni sastav je upoređen sa sličnim kolačima sa tržišta. Nakon proizvodnje analiziran je osnovni hemijski sastav, dostignuti kvalitet uzoraka muffina i odabran najbolji, koji je proizveden kombinovanjem sljedećih sastojaka: 32% integralnog pšeničnog brašna; 30% vode; 10% obranog mlijeka; 9% fruktoze; 5% suncokretovog ulja; 6,5% jaja; 3,2% kakao praha sa smanjenim sadržajem masti; 3% kvasca; 0,3% soli; 0,3% svake od aroma čokolade, vanilije i ruma; 0,16% mješavine aditiva. Muffini su imali visoku senzornu ocjenu kvaliteta (4,73±0,22 boda od 5 mogućih), karakterističan pravilan oblik i volumen, ravnomjeran raspored pora, umjerenu elastičnost i vlažnost u toku žvakanja, ujednačenu tamno smeđu boju, prijatan skladan miris i sladunjav ukus pečenog čokoladnog kolača. Zaključeno je da su muffini pogodni i bezbjedni za ishranu dijabetičara, kao i za zdrave osobe, u pogledu sadržaja osnovnih sastojaka (integralnog pšeničnog brašna, obranog mlijeka, fruktoze, biljnog ulja) i nutritivnog sastava sa smanjenim sadržajem energije 30-54%, masti 30-79%, šećera 67-80%, kada se uporede sa pet sličnih čokoladnih kolača dostupnih na tržištu. Predstavljena metodologija za razvoj novog proizvoda obuhvata definisanje recepture za proizvodnju kolača, izbor sastojaka, opis proizvodnog procesa, kao i uspostavljene standarde za očekivani senzorni i nutritivni kvalitet gotovog proizvoda. Potrebno je naglasiti da, osim spomenutih specifičnih karakteristika kvaliteta, muffin kao novi pekarski proizvod ima i dodatnu vrijednost jer je relativno jeftin i pogodan za proizvodnju u industrijskim uslovima. Predstavljene rezultati istraživanja mogu se koristiti kao model za dalji naučni rad i razvoj drugih novih prehranbenih proizvoda, namjenjenih odabranim ciljnim grupama potrošača.